1. **Aspects of Mon-Khmer Register**

Characteristic of many Mon-Khmer languages is the tendency towards complexity of vocalics often in association with what has come to be called *voice register*. This term was first used by Eugénie J. A. Henderson (1952) to describe contrastive syllables in Cambodian. These two registers with their associated features may be summarized as follows.

<table>
<thead>
<tr>
<th>Initial (written) Consonant</th>
<th>Voice Quality</th>
<th>Vowel Quality</th>
<th>Pitch</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Register (original) surds</td>
<td>normal head clear tense</td>
<td>more open, onglided</td>
<td>relatively higher</td>
</tr>
<tr>
<td>Second Register (original) sonants</td>
<td>deep breathy sepulchral chest relaxed</td>
<td>close, centering diphthongs</td>
<td>relatively lower (larynx also lowered)</td>
</tr>
</tbody>
</table>

*Chart 1*

The two series described here, that is the core relation set of the Indic-derived consonantal symbols associated with various vocalic phenomena, had earlier been observed by Haswell (1901), Blagden (1910), and Halliday (1922) for Mon, and by G. Maspero (1915) for Khmer (Cambodian). Blagden noted that in Mon the
nd series (associated with written sonants) is
der 'guttural' and is 'articulated from the rear
the mouth'. He cites J. M. Haswell's earlier
ervations that the second series was also pro-
ced in a 'softer' fashion. Halliday also re-
tized the existence of this basic division in Mon
ology, adding that the voiced initial series is
owed by a vowel with a 'deeper tone'. Maspero
b the previously described series features in
and confirmed that a substantially parallel
uation was true for Khmer.

More recently, Shorto (1966:399, 400) has said
for modern spoken Mon:

The paratonal register distinction is broadly sim-
ilar to that described for Cambodian by Henderson.
its exponents are distributed throughout the ar-
tulatory complex but exclude pitch features.
heast register, symbolized by a grave accent placed
ver the vowel (kèt, hakòa), is characterized by
reathy voice quality in association with a
eneral laxness of the speech organs and a
elatively centralized articulation of vowels.
he more frequent head register is unmarked in
he transcription (ket, hakoa); it is character-
ed by a clear voice quality, relative tenseness,
ad peripheral vowel articulation.

Another introductory text on Cambodian, Jacob (1968:4)
es the following description of register pheno-

There is potentially a distinction of voice quality
in the utterance of the vowels and diphthongs of
the two registers, those of the first register
being pronounced with a clear, 'head' voice and
a certain degree of tension and those of the
second with a breathy, 'chest' voice and a
comparatively relaxed utterance. This difference
of voice quality will, however, not be heard in
the speech of all speakers.
The term 'pharyngealization' has also been applied to register articulation. Noss (1966:92ff) says of Cambodian:

In Standard and Phnom Penh, all complex vowel nuclei (i.e. clusters and long vowels) which begin with a non-low vowel phoneme and remain at that level or fall lower, are, facultatively and non-distinctively, pharyngealized. (In the writing system this distinction is represented almost perfectly insofar as Standard is concerned by the selection of initial consonants.)

This apparently refers to the set called second register (or series) elsewhere. Pharyngealization in an apparently different sense, however, appears what Noss describes as a 'voiced pharyngeal spirant /H/ plus rising pitch' as the normal reflex of /r/ in Phnom Penh speech.

Jenner (1966:19ff) has surveyed some of the features manifesting register not only in Mon, and Khmer proper, but on a wider scale, including other lesser known Mon-Khmer languages of Southeast Asia. In commentary form, taking features attributed to register in these other languages, he draws comparisons or contrasts with articulations in Khmer. Here I summarize only the references to Khmer register phenomena. With reference to movement of speech organs, he says (1966:32):

The essential movements occurring in Khmer may be said to be (a) a lowering of the larynx and (b) a widening of the faucal pillars, both contributing to the distention of the pharyngeal cavity. I suspect that a third movement is involved, namely a narrowing of the isthmus faucium by backing the radix of the tongue toward the pharyngeal wall.

As for the locus of resonance (33), 'the effect of this complex action ...is to emphasize the role
the pharynx as a resonator'. On the question of tense-lax distinction he says (34), 'vowels with a resonance are typically lax while those with pharyngeal resonance are preponderantly tense. Such tenseness is presumably referable to the act of "stiffening the pharyngeal chamber". One notes in passing here that Jacob attributes tenseness and tension to the opposite registers from Jenner and Shorto's use of these terms for Mon parallels to that of Jacob for Cambodian. Turning now to pitch, Siver comments (35):

Whatever its historical rationale, pitch in modern Khmer appears to be an effect of the muscular tension already noted and a by-product of the essential actions involved in pharyngealization. The pitch of vowels uttered with oral resonance is normal, there occurring no articulatory activities to modify it. The pitch of vowels with pharyngeal resonance is low in relation to normal—which is tantamount to saying that during pharyngealization the frequency of vibrations of the vocal cords is retarded. This lowered frequency is accounted for partly, perhaps, by the general tenseness of the laryngeal zone and partly by a reversion of muscular effort to the lowering of the larynx. Normal and low pitch are relative, the interval between the two being three or four semitones.

Finally, on openness of the oral cavity this examination (36) is offered:

In Khmer, syllable nuclei that preserve oral resonances are articulated with the tongue in a lower position than their counterparts that have developed pharyngeal resonance. This is not the same as saying that pharyngealization has entailed raising of the tongue above its normal level, for generally it has been the Low Series nuclei that have suffered the greatest change. This lowering of the oral nuclei, while possibly attributable to the greater laxness which characterizes the Low Register, more probably reflects an urge (which pitch alone was unable to satisfy) to
reinforce the contrast between the oral and the pharyngealized nuclei. In order to see the general nature of this tongue lowering it is useful to view the two series of nuclei ... from the point of view of their development out of a former single set, represented ... with sufficient accuracy by their common Indic transliteration ... the nuclei ... of the High Register show less development away from their supposed prototypes than those of the Low Register.

It can be seen that the urge toward a lowered tongue postion in the Low Register has been fulfilled in two ways: (1) by the development of a low onglide before some oral vowels and (2) by a more or less perceptible lowering of the tongue with other oral vowels. When this lowering has been marked the change has resulted in functional contrast; when it has been less marked the change is merely phonetic.

In 1962 Phillips demonstrated that certain Mon-Khmer languages in Vietnam (specifically Mnong Buon, Hre, and Sedang) also possess register systems similar to those described for Cambodian and Mon. Further recent work on highland languages of Vietnam and Laos has revealed that the register phenomenon in varying forms has a fairly widespread distribution within the Katuic and North Bahnaric branches of Mon-Khmer (Miller 1967, Cooper 1965, Gradin 1965).

Historical reconstruction has established register as an original feature of North Bahnaric and perhaps Bahnaric as a whole (Smith 1972). Register characteristics of some of these languages are summarized in Chart 2.

While it is evident enough from the above discussion that many Mon-Khmer languages exhibit a basic phonological bifurcation and that the two classes have been labeled as contrastive, the traditional labels have often tended to be on the impressionistic side. This is not altogether surprising for, as a matter of fact, in a number
<table>
<thead>
<tr>
<th>Language</th>
<th>First Register</th>
<th>Second Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinh Bunor</td>
<td>tight,</td>
<td>loose,</td>
</tr>
<tr>
<td></td>
<td>lower vowel,</td>
<td>higher vowel,</td>
</tr>
<tr>
<td></td>
<td><em>fortis initial stops</em> (vl. and imploded)</td>
<td><em>lenis initial stops</em> (voiced)</td>
</tr>
<tr>
<td></td>
<td>vocal cords tense,</td>
<td>vocal cords relaxed</td>
</tr>
<tr>
<td></td>
<td>faucalization,</td>
<td>deep, muffled,</td>
</tr>
<tr>
<td></td>
<td>clear, bright,</td>
<td>breathy,</td>
</tr>
<tr>
<td></td>
<td><em>'natural'</em></td>
<td>(abnormal),</td>
</tr>
<tr>
<td></td>
<td>lower vowel (if different)</td>
<td>higher vowel (if different)</td>
</tr>
<tr>
<td>Kinh</td>
<td>tight,</td>
<td>looser, deeper (but not as deep as in Hre),</td>
</tr>
<tr>
<td>Nguyen</td>
<td></td>
<td>not pharyngealized,</td>
</tr>
<tr>
<td></td>
<td>pharyngealized (rasp),</td>
<td><em>'natural'</em></td>
</tr>
<tr>
<td></td>
<td>weak glottal stop preceding pharyngealization</td>
<td></td>
</tr>
<tr>
<td></td>
<td>clear quality</td>
<td>deep quality,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>relaxed faucal pillars,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lowered larynx,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>increased diaphragm pressure,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lower pitch,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>higher vowel</td>
</tr>
<tr>
<td>Kinh Nguyen</td>
<td>shrill,</td>
<td>breathy,</td>
</tr>
<tr>
<td></td>
<td>clear</td>
<td>having undertones,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>dark sounding</td>
</tr>
</tbody>
</table>
Register features in Mon-Khmer languages in Vietnam

<table>
<thead>
<tr>
<th>Language</th>
<th>First Register</th>
<th>Second Register</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rengao</td>
<td>sharply defined,</td>
<td>'deep' pharyngeal</td>
</tr>
<tr>
<td></td>
<td>oral (clear) resonance,</td>
<td>resonance,</td>
</tr>
<tr>
<td></td>
<td>pharyngeal cavity constricted,</td>
<td>pharyngeal cavity expanded,</td>
</tr>
<tr>
<td></td>
<td>larynx normal to high,</td>
<td>larynx lowered,</td>
</tr>
<tr>
<td></td>
<td>tongue root retracted,</td>
<td>tongue root advanced,</td>
</tr>
<tr>
<td></td>
<td>tongue blade lowered</td>
<td>tongue blade raised</td>
</tr>
<tr>
<td>Brou</td>
<td>tense,</td>
<td>relaxed,</td>
</tr>
<tr>
<td></td>
<td>slightly faucalized,</td>
<td>deep, muffled,</td>
</tr>
<tr>
<td></td>
<td>lower vowel</td>
<td>higher vowel</td>
</tr>
<tr>
<td>Pacoh</td>
<td>pharyngealized,</td>
<td>normal</td>
</tr>
<tr>
<td></td>
<td>faucalized,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>tense</td>
<td></td>
</tr>
</tbody>
</table>

Chart 2
the languages in question, the impressions created registral features are indeed dramatic. And certainly from a phonemic point of view, any set of consonants may serve to designate that A ≠ B. However, descriptions of register phenomena cited in the texts above have also referred to clearly articulatory features of the question. Taking this orientation towards the more concrete aspects of register as a base, I should like to suggest that such endeavors be more specific about the articulatory basis for Khmer register yield further insight into traditional problems in these languages (and perhaps even sound) - specifically, that a clarification of the nature of articulation in the pharyngeal region proves the unifying basis for the features associated with Mon-Khmer register.

Tongue-Root Articulation and Register Effects

Vocalic Openness

In an article on Akan, a West African language, M. Stewart (1967) has fixed on the tongue-root as primary articulator and its positioning as the basis of contrast between the two sets of vowels that occur in the vowel harmony characteristic of that linguistic area. The point of great interest in Stewart's approach by Stewart is that the tongue-root positioning correlates with vowel openness. That is, a tongue-root advance position pairs with close /i/ or /e/, while the more retracted tongue-root position occurs with open vowels. In a companion article stewart's, K. L. Pike (1967) elaborates on the nature of tongue-root position in relation to various ways of describing pharyngeal openness. He then goes on to explore the articulatory implication of having separate status to the degree of tongue-root
advancement at least partially independent of that of the tongue blade. Further, in an independent study of West African languages, Ladefoged (1964) provides cineradiographic evidence clearly revealing that the more open Igbo vowels are effected by a retraction of the entire tongue mass which simultaneously constricts the pharyngeal cavity. On the other hand, these tracings portray the set of close vowels as a result of a more advanced tongue body position which creates an enlarged pharyngeal space.

Interestingly, at the same time that Stewart and Pike were discussing West African vowel height and pharyngeal cavity correlations, Miller (1967) also published 'An acoustical study of Brou vowels', in which a complex Mon-Khmer vocalic system was described. In that paper first-register vowels, described as 'tense, slightly faucalized' are said to be lower in tongue height during most of their duration than corresponding second-register vowels, which have a 'deep, muffled, relaxed' quality.

A comparison of the spectographic first formant reading for Brou (Brü) (Miller 1967:156–8) and Twi (Pike 1967:138) further reinforces the notion that some common underlying similarity exists. Since in Brou Miller recognized no register contrasts on either low or short vowels, they are not listed in the following chart. For the sake of simplicity the offglides are also omitted.
TwI Vowels

_e Harmony Set_  
<table>
<thead>
<tr>
<th>Frequency</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75-200 cps</td>
<td>u (200 cps)</td>
</tr>
<tr>
<td>0-200 cps</td>
<td>o (200-300 cps)</td>
</tr>
<tr>
<td>0-200 cps</td>
<td>e (400-500 cps)</td>
</tr>
</tbody>
</table>

_Open Harmony Set_  
<table>
<thead>
<tr>
<th>Frequency</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.75-200 cps</td>
<td>i (250-300 cps)</td>
</tr>
<tr>
<td>0-200 cps</td>
<td>o (400-500 cps)</td>
</tr>
</tbody>
</table>

_Brou Vowels_  

_Second Register_  
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>i (400 cps)</td>
<td></td>
</tr>
<tr>
<td>e (600)</td>
<td></td>
</tr>
<tr>
<td>u (400)</td>
<td></td>
</tr>
<tr>
<td>o (520)</td>
<td></td>
</tr>
</tbody>
</table>

_First Register_  
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ei (720-400)</td>
<td></td>
</tr>
<tr>
<td>ei (880-640)</td>
<td></td>
</tr>
<tr>
<td>ou (760-440)</td>
<td></td>
</tr>
<tr>
<td>ou (560-400)</td>
<td></td>
</tr>
</tbody>
</table>

_Chart 3_

While Brou vocalics in general are of a higher frequency than Twi and exhibit extensive ongliding in first register, there is a clear parallel between sets that at once exhibit features of contrast-openness coupled with differing degrees of pharyngeal volume. The Twi open harmony set and the first register Brou vowels have consistently higher frequencies than their close harmony or second register counterparts.

Consider as further examples the vowel array of ao, a North Bahnaric language of Vietnam, in contrast with the harmony systems of the West can languages, Dagaari (Kennedy 1966) and (Grimes 1964:114).
Rengao

Second (Lax) Register

First (Tense) Register

\[ \begin{array}{ccc}
  i & u & e \\
  e & o & \varepsilon \\
  \varepsilon & a & \\
\end{array} \]

Dagaari

Close Harmony Set

Open Harmony Set

\[ \begin{array}{ccc}
  i & u & t \\
  e & o & \varepsilon \\
  \varepsilon & a & \\
\end{array} \]

Kru

Bright

Muffled-Pharyngeal Resonant

Bright

\[ \begin{array}{ccc}
  i & i & u \\
  e & e & o \\
  \varepsilon & a & \varepsilon \\
\end{array} \]

Chart 4

I suggest that the parallelism between Mon-Khmer and West African language vocalic sets is more than a superficial one. It is rather the result of an underlying articulatory complex common to both language groups. That this mechanical linkage between vocalic openness and pharyngeal volume has not been widely recognized among linguists until rather recently is hardly surprising. Linguists, concerned as they are with the code structure of language, often give insufficient attention to its signalling mechanisms. Unfortunately, too often this deprives the linguist of precisely the data he requires to solve the problems he considers central. More to the point in this case, however, is the fact that it is excessively difficult to determine with any sense of
tainty what is going on deep in the vocal tract. So we must seek help from experimental researchers equipped with instruments appropriate to the task.

Although study in the area of pharyngeal articulation is growing, its results are only beginning to be realized. H. M. Truby (1967:540) complains, for example, that even:

... the very latest phonetics texts ... still portray the pharyngeal volumes for all vowels the same—demonstrable ignorance of fact, especially in the face of considerable documentation to the contrary in publication.

A recent Cineradiographic study by Perkell (1969) of the physiology of speech production graphically reflects the co-functioning of tongue blade and tongue body in English. His description (1969: 195), including his quoted observations of others, goes as follows:

The concavity in the pharyngeal region could be caused by the upward and forward pull of the lower fibers of the genioglossus and by the upward pull of the styloglossus. As MacNeilage and Sholes (1964) write, "the posterior portion of the genioglossus muscle contracts to move the posterior surface toward the point of the jaw (thus widening the pharynx) particularly for vowels which exhibit a high tongue front position [/i/, /e/, /i/[sic], /oi/]". On the other hand, the convexity could be caused by contraction of the posterior fibers of the hyoglossus in conjunction with anterior fibers of the genioglossus to pull and "squeeze" the tongue body posteriorly. Acoustically, this concavity in the lower pharyngeal region for high vowels causes an increase in volume in the posterior portion of the vocal tract, and thus contributes to a lowering of the first formant frequency, which is the principal acoustic characteristic of high vowels.

Inconsistencies such as these in our understanding of speech physiology should also enrich our approach to the
analysis of phonological systems in many languages.

The phenomenon of systematic vocalic lowering has been of historical interest in Mon-Khmer studies from its beginnings. The explanation of this development has usually involved reference to the nature of the original initial consonants. Consider, for example, the statement that:

an original voiceless initial generates greater openness in timbre of the following vowel than does an original voiced initial (Coedes 1940-48: 67; emphasis mine).

Or again:

The earlier *[gɔ.k] yielded modern [kɔ.k] /kɔk/, the earlier *[kɔ.k] yielded modern [ka.k] /kak/, the voiced initial of *[gɔ.k] not affecting the original openness, the voiceless initial of *[kɔ. inducing a lowering of the tongue to /a:/]. Thus the register of the two nuclei, an intrinsic synchronic fact, is a reflex of the former nature of the initials (Jenner, 1966:143; emphasis mine).

In view of these explanatory statements, one is perhaps justified in wondering what the voicing status of a consonant has to do with tongue height, particularly in what seems to be a causal sense. To be sure there is a connection between voicing of initials and vowel height, but is it in some sense causal? Apparently not. Rather descriptions of this type are presumably meant to be interpreted as saying no more than that forms with modern contrastive vowel openness may be traced to historical precursors in which there is no written vowel contrast (in the Indic script), but in which an initial consonant contrast of voicing is symbolized. Thus initial consonants effect vowel changes only in some metaphorical sense. In view of the earlier discussion of the mechanics of tongue-root articula
It is suggested that tongue height is best explained in those terms. Moreover, as I will discuss below, consonant voicing also seems attributable such activity. That is, tongue-root retraction lowers the vowel and creates conditions favorable for voicelessness, while tongue-root advancement results in a higher vowel and a set of voicing conditions.

**Voice Quality (Resonance)**

The most striking phonetic features in many Khmer languages are those involving cavity resonance. Indeed, these features have come to be technically equivalent to the term 'register'.

In referring to West African languages, it is instructive to compare the 'choked' or 'strangled' articulations of the Twi open vowels with the 'tight', 'restricted', 'pharyngealized (rasp)', 'faucalized' quality of Mon-Khmer first register (open) vowels. Rather notice the terms 'hollow' applied by Stewart Twi close vowels and 'deeper' and 'fuller' with which Pike (1967:130) had previously described similar pharyngeal phenomena. These descriptions again to be compared with Mon-Khmer second register close vowels) where the quality has been characterized as 'sepulchral', 'deep', and having 'pharyngeal resonance'. It is further interesting that in Fante, a West African group related to Twi, there is the relation of 'unraised' vowel with 'creaky' voice quality and 'raised' vowel with 'breathy' voice quality. Incidentally, not unlike Henderson's approach, Cambodian register is Berry's analysis of Fante vowels, in which differences in aperture are considered secondary to differences in voice quality (Stewart 1967:169).
The articulatory basis for the auditory contrasts in West African languages has been identified as tongue-root movement. Advanced tongue-root produces an enlarged pharyngeal cavity, creating impressions of resonance focused in that region, while tongue-root retraction constricts the pharyngeal cavity, producing a reduced resonance there. For Khmer Jenner (1966:34) also associates pharyngeal resonance with 'the act of distending the pharyngeal chamber'. This expansion of the pharyngeal cavity is attributed by him (1966:32), however, to the lowering of the larynx and the widening of the faucal pillars. More tentatively, he suspects a third gesture, namely 'backing of the radix of the tongue toward the pharyngeal wall', may be involved in the pharyngeally resonant vowels. Pike (1947:21) has described the production of such 'deep' pharyngeal resonant sounds in terms of all three of the above factors. With reference to the action of the tongue root, however, he prescribes an advancement, not a retraction, to achieve a distended pharynx. It was precisely this observation by Pike which suggested to Stewart (1967:197) the direction in which to seek the basis of Akan vowel set articulation.

Pike (1967:131) finds no lowering of the larynx in the Asante-Twi speech he observed. Rather the cavity expansion seems to have been created solely by the forward thrust of the tongue body. On the other hand, such lowering is true of Khmer, Jeh, and Rengao (see charts above). The West African material suggests that larynx lowering is not necessary for the creation of an enlarged pharynx, tongue advancement being sufficient; however, Mon-Khmer material leads to the observation (as do Pike's original purely phonetic exercises) that there is
natural basis for cooperation of speech organs in this region to expand both out and down resulting in maximized pharyngeal volume. They are apparently independent, however. One may suggest that a marking relationship exists, such that with advanced tongue-root comes a natural expectation (but not requirement) of a co-occurrence of laryngeal lowering. On the other hand, tongue-root retraction entails no such expectation; co-occurrence would be a 'marked' relationship.

Briefly summarized then, the auditory facts of Khmer register contrasts seem quite naturally wed as based on the advancement or retraction of tongue-root. Advancement produces the deep laryngeal qualities of the Second (High) Register retraction produces the more constricted effects of the First (Low) Register. Laryngeal lowering is wed as a natural, but independent and optional articulation with advanced tongue-root position. It is also a satisfying conclusion that tongue height and voice quality are both essentially correlative aspects of the same articulatory gestures.

The above conclusions concerning the basis of voice quality stand in contrast with historical and phonological explanations. For example, Pinnow, 'The voiced stops have lost their voicing ... compensate for this shift, words of the Second register are now pronounced in a deeper voice' (noted in Jenner 1966:107). I hope to show below (§2.3) that resonance features such as 'deep voice' are not just arbitrary replacements for some obvious different phonetic cue, but rather share with the consonants a common articulatory basis,
namely tongue-root position.

It was a preoccupation with resonance features to the exclusion of their basis that obscured initial research on certain Mon-Khmer languages of Vietnam. Grdin (1966:41, 42) in his early work on Jeh described it as possessing 'deep vowel quality ... which parallels the laryngealization of Sedang and the breathiness of Halang...'. Later studies (cf. Smith 1968:60) revealed that from a comparative point of view the parallelism was superficial. It was true that Halang breathiness and Jeh deep vowels corresponded, but not Sedang laryngealization. One does not have to look far for the basis of such faulty parallelisms. Jenner (1966:31), after summarizing register descriptions then available on several Mon-Khmer languages, is clearly correct in concluding that 'the common thread through these descriptions is articulatory action of a kind that sets up resonance of an "abnormal" kind which contrasts with "normal" oral resonance'.

One may now ask how helpful the opposition 'normal' vs. 'abnormal' is in understanding register effects. In Khmer the First (Low Vowel) Register is 'normal', while the Second (High Vowel) Register is 'abnormal' (pharyngeally resonant). But it is the 'abnormal' register vowels that most closely reflect what seems to be symbolized in the writing system, while the 'normal' register vowels behave in a most 'erratic' fashion. Certainly terms 'normal' and 'abnormal', whatever virtues they may have simply as tags for contrastive registers, give no insight into the nature of the features (e.g. aperture, resonanc etc.) with which they correlate.
The parallelism first suggested for Jeh, Halang, and based on 'normal' vs. 'abnormal' auditory impressions must, on both synchronic and historical-comparative grounds, be replaced by the array in Chart 5.

<table>
<thead>
<tr>
<th>Second (High Vowel) Register (tongue-root advanced)</th>
<th>First (Low Vowel) Register (tongue-root retracted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>abnormal (deep, pharyngeal resonance)</td>
<td>normal (clear)</td>
</tr>
<tr>
<td>lang (breathy, pharyngeal resonance)</td>
<td>normal (clear)</td>
</tr>
<tr>
<td>lang normal (clear)</td>
<td>abnormal (laryngeal-ized, pharyngeal-ized rasp)</td>
</tr>
</tbody>
</table>

Chart 5

Note now that Jeh and Halang Second Register is pharyngeally resonant and thereby 'abnormal', while lang Second Register is not pharyngeally prominent in any way and is by virtue of that fact 'normal'. The other hand, the Jeh and Halang First Register conveys no exaggerated pharyngeal impressions and should be declared 'normal', whereas the Sedang First Register has some sort of laryngeal and pharyngeal quality and sounds 'abnormal'. From the point of view of the normal : abnormal dichotomy this appears to be a reversal--some kind of phonological p. Actually, that is not the case. There is a wing which we may diagram as Chart 6.
Phonologically, each of these three languages has a register opposition based on tongue-root position. Unfortunately, the pharyngeally expanded resonant pronunciation of Jeh and Halang as well as the pharyngeally constricted one of Sedang had both been lumped together as 'abnormal'. They are abnormal, but for opposite reasons phonetically. That is, Jeh and Halang advanced tongue-root position is well advanced from a central tongue body posture, while its retracted position is perhaps only slightly drawn back of that central position towards the pharynx wall. On the other hand, Sedang's advanced position is in the neighborhood of a central tongue-root position, while its retracted position is well drawn back towards the pharynx wall. Thus there is no conflict between phonological and comparative facts among Jeh, Halang and Sedang. Jeh, Halang Second-Register forms with a well advanced tongue-root (abnormal) are cognate with Sedang Second-Register forms with slightly advanced tongue-root (normal) pronunciations.
ilarly, Jeh, Halang slightly retracted (normal) relate with Sedang well retracted (abnormal) ones. short, even though Jeh and Halang tongue-root range more fronted, while that of Sedang is more backed, opposition tongue-root advanced: tongue-root retracted remains.

Consonant Voicing

The correlation in Mon-Khmer of voiced initial sonants with Second (High Vowel) Register and voiceless or glottally affected consonants with first (Low Vowel) Register is well-known (cf. Chart 1 Mnom in Chart 2). Historically the contrast is reflected in the written contrasts in Cambodian and Indic based scripts. The same correlation is a chronic fact in Mnom, where the distinction between voiced and voiceless initial consonants has been interpreted as rendering the other register features (vowel height and voice quality) predictable hence subphonemic. This modern situation in Mnom seems to nearly portray the set of relationships that earlier existed in Mon and Khmer prior to the voicing of initial consonants.

The written initial consonants of Khmer and Mon,alling as they do the same set of morpheme distinctions as are synchronically manifested by other register features (voice quality, pitch, vowel aper- e), are generally taken as a phonological given, from which to derive modern register features. It not been considered meaningful to inquire why voiced consonants correlate with Second (High Vowel) register and voiceless consonants with First (Low el) Register. The study of the mechanics of gue-root articulation, however, leads to the gestion that the original voicing status of
initials is more than an arbitrary starting point for subsequent phonological contrasts. Let us assume that, rather than several register features issuing from the one voiced: voiceless opposition in some sequential sense, all the features (voicing, pitch, vowel aperture, and voice quality) coexisted (as in modern Mnong), constituting a multi-feature prosodic opposition dichotomizing all syllables (or phonological words). It is suggested that all of these phonetic features are effects of an underlying opposition between tongue-root advancement vs. tongue-root retraction. Voiced initials are an effect of advancement and voiceless initials of retraction of the tongue body.

The positioning of the tongue body has already been described as having a natural reciprocal effect on the position of the tongue blade (vowel height). It is hypothesized by Perkell (1969:57) that 'the intrinsic musculature has little function in vowel differentiation'. Rather vowels are produced by the action of the extrinsic musculature in positioning a semi-rigid tongue body in the speech tract. On the other hand Perkell (1969:65) says:

Consonant production can be thought of as being accomplished by the action of both the extrinsic and intrinsic systems. As in the case of vowel production, the tongue body (or lips) must be positioned to enable a particular part of the tongue or lips to accomplish the specified articulation. For this reason, coarticulation effects of vowels are, for the most part, manifested by influencing the position of consonant-articulating organs rather than by altering the manner of articulation. Thus the positioning element of consonant production is performed by the slow extrinsic system and is strongly influenced by coarticulation effects. This positioning aspect presumably also operates to produce secondary features of consonant articulation such as palata-
Identification, labialization, and pharyngealization.

As, as suggested by Öhman (Perkell 1969:65), 'the production of a consonant can be thought of as being gesture superimposed on the continuously varying vel-producing system'. Looked at slightly differently, vowels and consonants are dependent on common mechanism—tongue body positioning musculature—as fundamental for their production. This precisely the parameter we have been investigating this paper, *i.e.* tongue-root advancement vs. tongue-root retraction.

It is no novel observation that vowels and consonants have similarities and mutually affect one another. As noted above, point of articulation assimilation is well-known between consonants and vowels. But the Mon-Khmer correlation involves tongue as a coarticulation feature of vowel aperture, voice quality, and pitch. Can this be explained as tongue-root positioning effect? I think it can.

It has been pointed out (*e.g.* Perkell 1969:33-4; pmsky and Halle 1968:325) that the degree of pharyngeal widening during consonant production varies depending on the particular consonant. In particular, these references involve voiced 'lax' voiceless 'tense' consonants, where the former systematically exhibit a wider pharynx cavity than the latter. Clearly, this accords with Mon-Khmer voicing and pharyngeal correlations in each register.

To inquire further, what is there about an advanced tongue body that it is compatible with voicing or a retracted tongue body that it is compatible with non-voicing?
The answer to our question perhaps involves the matter of air stream movement in speech production. Chomsky and Halle (1968:326-7) explain:

In order for the vocal cords to vibrate, it is necessary that air flow through them. If the air flow is of sufficient magnitude, voicing will set in, provided that the vocal cords not be held as widely apart as they are in breathing or in whispering.

This is based on the fact that (Chomsky and Halle, 1968:300) 'the two major factors controlling vocal cord vibration are the difference in air pressure below and above the glottis and the configuration of the vocal cords themselves'. If there are no significant constrictions in the air passage, the lungs may freely drive air through the glottis, creating a vocal cord vibration. On the other hand, if there is a constriction in the vocal passage which resists the flow of air, the vocal cords return to a non-vibrating closed state since no air movement forces them apart for voicing. That is, a voiceless state exists. Since the air initiating mechanism continues to exert force, subglottal pressure does, however, continue to build until a threshold is reached where the vocal cords are forced apart in a rapid expulsion of air. This correlation has been noted by Lisker (cited in Chomsky and Halle 1968:326, fn. 29), who says: 'The rate of pressure build-up is significantly slower for voiced stops than for voiceless.'

In view of these observations it seems possible to suggest that the advancement or retraction of the tongue-root can constitute a major air stream regulator. In a forward position the tongue body ideally raises vowel height, produces enlarged resonant
rynx cavity, and permits the uninhibited flow of air through the glottis for voicing of consonants. Conversely, in a retracted posture the tongue body raises, increases tongue height, reduces pharyngeal resonance, restricts the flow of air, thereby producing a voiceless state for consonants. Specifically, the glottis with its mechanical linkage to the tongue hyoid bone may play a significant role in controlling air movement (cf. Heffner 1960:19).

It has been noted that the registers in Mon- gol are characterized as involving some kind of tense vs. lax opposition (cf. charts 1 and 2). The relation of voiced consonants with the lax register and the voiceless and imploded consonants with the tense register accords with a general phonetic ob- servation that:

tense phonemes are articulated with greater distinctness and pressure than the corresponding lax phonemes. The muscular strain affects the tongue, the walls of the vocal tract and the glottis. The higher tension is associated with a greater reformation of the entire vocal tract from its neutral position (Jacobson, Fant, and Halle 1961: 8).

Nesky and Halle (1968:325) describe the possibility of voicing to take place as a function of the tense- ness of the vocal tract. Again this involves the release of air stream pressure and movement through the glottis. With a supraglottal constriction, pressure above and below the glottis rapidly equalizes and the vocal cords no longer vibrate with the passage of air through them if the vocal tract is rigidly constrained by strong muscular tension. On the other hand, a generally lax vocal tract allows aspiration as pressure builds and thereby permits a
continuing vocal cord vibration, i.e. voicing. Certainly compatible with this interpretation of tenseness is the observation that in Mon-Khmer the 'tense' First Register, for which tongue-root retraction neatly explains vowel height and voice quality, manifests voiceless consonants, while the 'lax' second register, based on tongue-root advancement, manifests voiced ones. From this point of view one may agree with Lisker and Abramson (1971:775) that pharyngeal enlargement need not merely be a 'passive response' to sub-glottal pressure, but is rather an 'active adjustment', i.e. tongue-root positioning.

In spite of the apparent applicability of tenseness vs. laxness to consonant voicing in Mon-Khmer, there are some infelicities, too. The problem is that in the 'lax' Second Register consonants are voiced, but vowels are high (close) and in the 'tense' First Register consonants are voiceless (or imploded) but vowels are low (open). When these lax register higher vowels are long, their production entails a certain visible flexing and bulging under the chin above the larynx. Stewart (1967:196ff) calls this 'chin lowering' for the tongue-root advanced vowels of Twi and feels that it fits Hockett's (1958:78-9) description of tenseness in European vowels. Hockett points to the 'bunching and tension in the muscles' under the chin above and in front of the glottis during the articulation of English beat versus the absence of such muscular action in bit. However, if West African tongue-root advanced ('raised') vowels are tense by this measure, one is left with Stewart's (1967:196) hesitation about tenseness in general:
On impressionistic grounds I have always felt uneasy about applying the lax/tense terminology to Twi or Fante as some of the unraised ('lax') vowels, particularly the high ones I and U, have often struck me as choked or even strangled.

The effect of this is that Stewart now has two types of tenseness—one that manifests itself in the 'strangled', 'constricted' pronunciation of the open unraised vowels, and one that appears as the muscle bunching under the chin for the close ('raised') vowels. One is then faced with a choice of which particular activity to focus on in applying the tense lax terminology. In my opinion, Stewart makes the right choice in taking yet a third alternative by abandoning tense/lax as a distinctive feature and stating the basis of his phonological opposition directly in the articulatory movements themselves, e.g. tongue-root position. In that case, tenseness best applies redundantly and at worst is relegated whatever other uses impressionistic terms can be.

In conclusion, then, I suggest that for Mon- ner also the explanation of register phenomena such voicing of consonants or positioning of vowels is not founded on explicit references to specific speech articulations (tongue-blade, tongue-root) and air movements (up: down, backward: forward) and at other harder to define notions like tenseness, as they often seem, be given secondary status.

The view that voicing is fundamentally associ- with the management of pressures in the vocal tract above and below the larynx has long been held phoneticians (cf. Stetson 1951:37, 38, 50). It essentially this assumption which is accepted by Msky and Halle (1968). However, more recently a number of investigators have argued that laryngeal
activity can be initiated independently by the intrinsic musculature of the larynx itself. This same line of reasoning, by the way, applies not only to voicing, but also to pitch. Lisker and Abramson (1971), representing something like an 'autonomous larynx viewpoint', for example, say:

We assert the possibility, in the absence of evidence to the contrary, that the speaker exerts some control over the timing of voicing onset by determining the close down of the glottis. In absolute initial position ... it seems not unreasonable to suppose straightforward control of the timing of contraction of certain of the laryngeal muscles.

The position taken by Lisker and Abramson appears to be a healthy reaction to a general view, in which laryngeal control is said to be basically outside the larynx itself. Now, however, the danger would seem to be a theoretical stance in which the larynx is held to function completely independently of other articulators. The authors cited do not as a matter of fact espouse the most extreme position. Rather they are really doing no more than seriously questioning the 'dependent larynx' idea in view of the present incomplete state of knowledge on the topic.

While it is possible to assume that the larynx independently receives instructions from the brain to initiate vocal cord vibrations while the tongue base is advanced, and to cease such activity while the tongue is retracted in the Mon-Khmer register systems, it seems wiser, from a methodological point of view, to first ask whether there is a natural basis for a non-fortuitous cooperation between tongue and larynx. That is, considering the extent to which the muscular and neural systems of the
gues and larynx are harnessed together, one would ect interaction rather than independence to racterize many of their relationships. Deeper erstanding of these connections will hopefully d light on the question of voicing in the context tongue-root articulations.

In addition to plain voiceless consonants, loded (glottalized) sounds are also usually Mon- er First Register correlates. Phonetically, im- sives belong to a class of ingressive suction ements. Typical of the production of clicks and losives is the role of tongue retraction in pro- ing a rarified outer cavity and a highly ssurized inner cavity. The backward movement the tongue cooperating with downward movement of vibrating glottis is specifically described for ma, an African language (Chomsky and Halle 8:323). The rapid and extensive laryngeal low- ing with ingressive air in the First-Register for losives is in contrast with the lesser laryngeal ering with egressive air that accompanies pharyn- nal expansion in the Second-Register. The common ominator between other voiceless sounds and the loded ones seems to be that the period of onset articulation in which the larynx is lowered is a celess one. This is terminated by a rapid ttal release as the subglottal pressure is re- ed and voicing of the consonant begins.

As for the role of tongue posture during implo- e articulation, one may suggest that the vacuum ated in the pharynx by the descending larynx ates forces favorable to at least some degree retraction. Greenberg (1970) has noted that in eral the bilabial point of articulation is the
most favored. Of course, this leaves the tongue free to follow whatever other forces may be brought to bear on it. Greenberg further notes that a retroflexed consonant is the next most common implosive. This clearly reflects tongue retraction and in some cases such retroflexion is considered more distinctive than the implosion. Velar implosives, on the other hand, are apparently rare. Certainly this is true in Southeast Asian languages. But this would seem to be a major retracted articulation and thereby be expected to appear frequently with implosion if, indeed, retraction and implosion are naturally linked. If the tongue body retraction involved in implosives is acting in concert with the forces created by laryngeal lowering, the tongue movement may be expected to be not only back but also down. Velar articulation, however, requires a high arching of the tongue dorsum in contrast to the lower profile of dentals and labials. In at least one set of English cineradiographic tracings in Perkell (1969:58), the pharyngeal constriction was no greater for a voiceless velar than for a voiceless dental and even less than for a voiceless bilabial stop. Perhaps again, as in the case of vocalic effects of tongue-root movement, the most natural tongue body path describes a 'slanting line' from high front in advanced position to low back in retracted position. This route would render the bypass of velar implosives a not unexpected tendency.

2.4 Pitch

Pitch as a register feature is reported for Khmer as 'relatively high' in First Register and 'usually lower' in Second Register (Henderson 1952:51). Lower pitch in the Second Register as well as a rising pitch associated with final /-h/ is
ported for Jeh (Gradin 1966). Level vs. falling
 tones are reported to correlate with original surds
 sonants, respectively, in Riang (Luce 1965).
 Vietnamese, similarly, reflects a high set of tones
 associated with voiceless initials and a low set
 associated with voiced ones (Maspero 1912:102). For
 er and Jeh a classic register set exists, includ-
 ing pitch. For Riang, Vietnamese, and other Mon-
 er languages, the familiar vowel effects of
 register are not reported, though the pitch-consonant
 tial correlation exists. Of course, the latter
 widespread in Asia outside Austroasiatic. In the
 case of Vietnamese, however, there are a number of
 examples of vowel correspondence with classic register
 guages in which the lowered First Register vowels
 are low reflexes in Vietnamese. This suggests that
 Vietnamese may once have had the fuller set of reg-
 ister features, but lost all but tone. The same
 e of reasoning can be used to show that non-register
 guages of Vietnam once possessed register, which
 since disintegrated into a simple vowel contrast
 tem (in these cases minus pitch). Consider
 Chart 7.

 The sample comparisons in Chart 7 involve spe-
 cifically the high front and back tongue-root
tracted register vowels, since they give the most
omatic evidence of 'downward migrations' in vocalic
ce. There is enough lowering in Vietnamese to
suggest tentatively that such correspondences are
ountable as former allophones of /i/ and /u/ in
iginal tongue-root retracted register syllables.
has all been to say that Vietnamese, a 'tonal
guage', gives some evidence of deriving its
iginal pitch sets from the same articulatory
<table>
<thead>
<tr>
<th>Register</th>
<th>Non-Register</th>
<th>Tonal</th>
<th>Glosses for Example</th>
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<tbody>
<tr>
<td>*piq (OMon)</td>
<td>pe (Bahnar, Chrau)</td>
<td>ba (VN)</td>
<td>'three'</td>
</tr>
<tr>
<td>pi (MMon)</td>
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<tr>
<td>/pi/ [pei] (Rengao)</td>
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<td>/bel/ [belal]</td>
<td>pele (Bahnar)</td>
<td>le (VN)</td>
<td>'bamboo'</td>
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<tr>
<td>mi (Mon), me (OKhmer)</td>
<td>meq (Bahnar)</td>
<td>me (VN)</td>
<td>'mother'</td>
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<td>/miq/ [meiq] (Rengao)</td>
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<td>cf. kmie (Khasi)</td>
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<tr>
<td>*turow (OMon)</td>
<td>*prəw (Proto-South Bahnaric)</td>
<td>sau (VN)</td>
<td>'six'</td>
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<td>tarau</td>
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<tr>
<td>/tədru/ [tədrou] (Rengao)</td>
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<tr>
<td>*appo' (OMon)</td>
<td>(h)apo (Bahnar) (chîem-)</td>
<td>bao mông (VN)</td>
<td>'dream'</td>
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<td>lapa (MMon)</td>
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<tr>
<td>/həpu/ [həpoou] (Rengao)</td>
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<tr>
<td>*pan (Mon); pon</td>
<td>*puən (Proto-South Bahnaric)</td>
<td>bôn (VN)</td>
<td>'four'</td>
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<td>/pun/ [poon] (Rengao)</td>
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<tr>
<td>cf. Munda upun; Sak. humpun</td>
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Chart 7
ditions that exist in the 'register languages'.

As mentioned earlier in connection with voicing, whole question of laryngeal control and pitchduction is a vexed one. Lieberman (1967) has
iced considerable emphasis on the role of subglottal
sure as affecting fundamental frequency or pitch.
refoged and Ohala (1970) and Fromkin and Ohala
68), on the other hand, while not denying the
ects of subglottal pressure, rather attribute to it
ore ancillary role. For example, Ladefoged and
ila (1970:25) say: 'at least 90% of the linguisti-
ically significant pitch patterns in English sen-
ces are effected by means of controlled changes in
aryngeal muscles.' Again, Fromkin and Ohala
68:103) say:
subglottal pressure could account for only about
or 10 per cent of the observed $F_o$ change en-
tcountered on the stressed or accented words. This
eads us to conclude that the laryngeal musculature
ays a more important role on $F_o$ regulation in
peech than does pressure.

Mon-Khmer languages which clearly exhibit the
er register features more easily traceable to
e-gue-root movement (vowel height and voice quality
icially), pitch is never a major feature. It is
en often absent than present in register descrip-
s in various languages. This may be interpreted
ome kind of support for the view that laryngeal
ities are at least partially independent of
e movement. Yet when pitch does figure, it is
er for First Register, lower for Second Register
ication. This leads to the assumption that
re must be some natural basis for their co-
ence. The question is not so much whether higher
ch can be initiated by the laryngeal musculature
alone in a given instance as it is whether some other set of conditions can also be a pitch raising or lowering factor. It is worth noting that Ladefoged and Ohala (1970:12-13) recognize not only subglottal pressure, vocal cord stiffness and mass, but also supraglottal impedance, as factors affecting the frequency of vocal cord vibration. They say, however, that

When a subject alters his articulation, he alters not only the supraglottal impedance, but also, in some cases, the tension of the vocal cords. In saying vowels such as /i/ and /u/, and consonants, there are noticeable changes in the configuration of the laryngeal tissues which we must assume have a definite effect on the tension of the vocal cords.

This implies that an extreme tongue gesture can produce more glottal tension than a less extreme one and thus contributes toward greater vocal cord vibration. If in a given language /i/ and /u/ are produced with greater effort of the (extrinsic?) musculature of the tongue than /a/ is, the former have a slightly higher pitch than the latter. This seems to be the case in a number of languages, including those of West Africa. The interesting question there, however, is not whether /i/ and /u/ are higher in pitch than /a/, but whether the tongue-root retracted allophone of /i/ is higher or lower in pitch than the tongue-root advanced allophone of the same phoneme. In Rengao, a Mon-Khmer language of Vietnam, the sharp low onset of First Register vowels by the retraction of the tongue is a distinct muscular action that is noticeably more vigorous than any Second Register gesture. On this basis First Register has been called 'tense' and Second Register 'lax'. In Rengao the First Register varia
## Tongue-Root and Marking Relations

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<tr>
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<td>Root forward</td>
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*Chart 8*
of /i/, [ëi], exhibits greater muscular effort or tension than does the Second Register variant of /i/ [i]. Pitch differences are not noticeable to the unaided ear in Rengao, but if, as Ohala and Ladefoged seem to suggest, higher pitch may be triggered by articulator tension, then it is the tongue-root retracted First Register that should be affected. As we have noted, this is indeed the register so affected in other Mon-Khmer languages. The question of 'tenseness' is, however, as usual a slippery one to deal with systematically.

Regarding the relationship of tongue-root movement and laryngeal function (both voicing and pitch), it seems possible to say that a fundamental liaison exists between them such that it is natural though not inevitable, for certain cooperative activities to take place in speech production. At present, the exact mechanics of that relationship are a matter of debate. Even so, certain possibilities that have been suggested in the literature lead one to the conviction that the tongue-larynx factors in Mon-Khmer register are not merely accidental correlates, but rather natural collaborators. I therefore suggest that certain features associated with register phenomena (or comparable systems in other languages) may be said to possess certain natural relations among themselves but are most notably tied to tongue-root articulation. These marking relations are to be interpreted such that an unmarked (U) relationship is expected, presumably because it has a natural physiological basis, while a marked (M) relationship is less expected, for the same reason. Chart 8 expresses the set of associations I have in mind.
Vowel Harmony

In his description of Cambodian grammar, Huffman (7:58-62) says:

many derivatives of disyllabic shape, the series of the affix vowel is determined by the series of the base vowel. In a smaller number of forms, the series of the base vowel is determined by the series of the affix vowel. This kind of conditioning is defined here as vowel harmony.

plifying the base vowel conditioned by an affixes /muc/ 'to submerge' and /prómc/ 'to put r'. An instance of the prefix vowel being conditioned by that of the base is illustrated in the s /cék/ 'to bite' and /cócék/ 'to peck at' in t Register, as compared with /cruš/ 'to exceed' /cócruš/ 'excessively' in Second Register. That /co-/ alternates with /co-/, depending on the ster of the base vowel. Consonants are involved part of the 'conditioning' environment for affix l alternation. For example, /-ɔm-/ alternates /-um-/ as a causitive infix: /-um-/ occurs with s in which there is a Second Register vowel and second consonant of the base is a sonorant; /-ɔm-/ rs elsewhere.

In the Jadrap dialect of Rengao a general vowel oney also exists. In this case the presyllable determined by the main syllable vowel and register. presyllable in general has the shape C-., where a non-contrastive vowel. While CëCVC is the l pronunciation for all words of both registers, e is a variant system in which CëCVC is appro- te for all Second Register words and those with t Register high vowels, but ÇaCVC or CëCëC, C, and CëCëC are found in words with First ster low vowels.
While vowel harmony has not been generally reported for Mon-Khmer languages, I wish to suggest that like the previously discussed features of register, this phenomenon too is a natural concomitant of a system which exploits tongue-root articulation. In the West African languages, it will be remembered, it is precisely a vowel harmony function that traditionally defines the set of tongue-root advanced vs. tongue-root retracted vowels. The question is, what connection does vowel harmony have with the movement of the tongue body?

To answer this question, let us return to the model of speech production referred to earlier in which consonant articulation is thought of as an activity superimposed upon the vowel producing system. Perkell (1969:61) says:

... the tongue is more active in consonant articulation whereas the body of the tongue is active in articulating both consonants and vowels.

He goes on to add:

The general differences in velocity, complexity, precision of movement, and in anatomy suggest that different types of muscles are generally responsible for consonant and vowel production. It is probable that articulation of vowels is accomplished principally by the larger, slower extrinsic tongue musculature which controls tongue position. On the other hand, consonant articulation requires the addition of the precise, more complex and faster function of the smaller intrinsic tongue musculature.

Let us add to this the observation attributed to Öhman (Perkell 1969:64) that the '(time) unit of natural speech encoding is more the size of a syllable than a phoneme'. Vowel harmony implies that the syllable is perhaps only a lower limit for speech timing.
In view of these observations on physiology and acoustic transmission, we may diagram sample relationships of the tongue body and the tongue blade through successive stages of state in speech production as Chart 9.

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<td>C</td>
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<td>C</td>
<td>V</td>
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<td>C</td>
<td>V</td>
<td>C</td>
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<td>stages of tongue body movements (state of extrinsic articulation)</td>
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<td>2</td>
<td>RETRACT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Charts 1, 2, 3, etc., represent temporal sequence change of state of the articulator named to the tongue blade. Notice that the tongue body exhibits a lesser frequency of change of state than does the tongue root or tip. While this over-simplifies the mechanics involved, it does portray the idealized situation in which the basic body set moves relatively little (perhaps often phonemically non-contrastive) while the upper part of the tongue moves through relatively more phonemically contrastive sets of articulation. In State 1 the tongue root retracts as in Mon-Khmer Second Register. As thisure is maintained, a sequence of consonants and 1 adjustments are made by the tip and blade. This were Mon-Khmer we would expect to have the initial consonant voiceless or glottalized and the blade relatively close. As the speaker produces the end word, the tongue body retracts to State 2, and again it maintains its basic set through a series of more rapid gestures by the upper tongue.
This time, however, two of these non-contiguous blade gestures produce vowels. But since the tongue root state has been roughly the same throughout, these vowels share something that was not possible in State 1. Namely the blade reach for both of them has been restricted (lowered) in a way not true of the same blade gesture in State 1 with the tongue body forward. This means that all blade actions dominated by one root position describe a certain articulatory range, while those of another root position describe a different one. This is a natural basis for vowel harmony.

That the basis for vowel harmony is tongue-root articulation in West African and Mon-Khmer languages suggests that it may be a relevant factor in other languages as well. For example, descriptions of Mongolian vowel harmony in the literature yield certain parallels. In Mongolian the harmonizing feature is tongue advancement with reference to both consonants and vowels. Lightner (1965:244-50) has advocated the use of a word-root marker GRAVE to yield a prosodic specification in the base forms. Stuart and Haltod (1957:87) earlier had said:

were there no exceptions we might describe Mongolian with only four vowels, i.e. /a, o, u, i/, plus two opposed characteristics (front:back) appertaining not to the phoneme segment but to the word. The rules of vowel harmony hold sufficiently well, as it is, for words violating these rules to be definitely conspicuous. [Emphasis mine.]

They go on to note that native grammarians call the back group 'masculine' and the front 'feminine'. one follows their suggestion and posits these basis vowels, how are the parameters to be labeled? Presumably something like the following:
then what does the suggestion about multiplying whole set by another front-back word factor mean? Apparently, for example, the high front unit must have a further sense in which it is 'front' 'back', the high back u must again be further specified as to 'front' or 'back'. An examination of the supposed tongue positions (Stuart and Haltod 7:83) will perhaps be helpful [lines connecting velar counterparts are mine]:

Minimum tongue aperture

Maximum tongue aperture

interesting fact is that what are the back set vowels are equally and perhaps more significantly a lower set of vowels. Note that historically there was apparently an earlier pair of i vowels, they are not now distinguished. The allophonic raising of i before ng (Stuart and Haltod 1957:81) however, probably significant, being a tongue retraction environment. In view of the general vowel raising connected with tongue-root retraction noted elsewhere, a similar interpretation seems inviting in Mongolian. Thus an underlying tongue blade front-back contrast would be distinguished from a nose root front-back distinction and could be
shown schematically as:

<table>
<thead>
<tr>
<th>tongue blade</th>
<th>tongue-root front</th>
<th>tongue-root back</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>front</td>
<td>back</td>
</tr>
<tr>
<td>blade high</td>
<td>i</td>
<td>ü</td>
</tr>
<tr>
<td></td>
<td>i</td>
<td>u</td>
</tr>
<tr>
<td>blade low</td>
<td>ä</td>
<td>ö</td>
</tr>
<tr>
<td></td>
<td>a</td>
<td>o</td>
</tr>
</tbody>
</table>

The flatness (roundedness) feature, then, rather than being a major feature as in Lightner (1965) would be predicted by the very natural general rule that blade-front vowels are unrounded (-flat) and blade-back vowels are rounded (+flat).

Another example of vowel harmony is found in Nez Perce. Zwicky (1970:116) arrays the vowels as:

```
i
\|\u
| o
| ä
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The vowels I have connected by lines are harmonic counterparts, the lower or backed ones forming a class called dominant and the upper or fronted ones a class called recessive.

If a word contains a dominant morpheme (one with dominant vowels), all vowels in the word are dominant. Some morphemes with the vowel i are dominant, some recessive. (Zwicky 1970:116.)

Note, not unlike Mongolian above, i does not take a phonetically distinct counterpart. This fact becomes important in the analysis of Zwicky and others in attempting to propose a natural underlying system in which i has both dominant and recessive
Plants that are plausible. The features which are employed to define the system are high, low, back, round. Some of the main underlying systems ered are these:

Rigsby-Silverstein system

Rigsby-Silverstein revised system

Rigsby-Silverstein variant

Jacobsen system

Chomsky and Halle (1968:372) declare that /i, a, and /i, ø, u/ are 'not natural classes in any reasonable phonetic framework' and their categorization should not be based on phonetic features. They pose an ad hoc diacritic feature /H/ to distinguish two sets. If, however, one posits an underlying tongue-root position contrast as the basis for vowel harmony in Nez Perce, as it appears to be in the other languages described above, one must conclude: the sets rejected by Chomsky and Halle are very natural classes and that it is the phonetic framework is not 'reasonable.' If, as in Mongolian, there is lost historical alternation even for /i/, the cases become even more convincing. It appears: the palatalizing effect of some /i/’s on consonants (Zwicky 1970:124-5) does reflect such an earlier state of affairs. The logic of tongue-root calculation would, then, seem to indicate that any
of the three alternatives for underlying systems above except the first Rigsby-Silverstein system would be plausible. Zwicky prefers Jacobsen's system, but if we abandon the attempt to describe the vowel pairs only in terms of blade position (high, low, back) and turn to tongue-root factors, it does not matter much whether the retracted variant of /i/ was /ə/, /e/ or /i/---all are tongue retracted in opposition to the other tongue root advanced variant. The analysis of vowel harmony systems in a number of other languages may also become less complicated if the tongue-root dimension is incorporated.

The observations of this paper were first written in a working paper done at a Summer Institute of Linguistics workshop at Nhatrang, Vietnam, in 1969. The current version expands and updates that study somewhat. I have especially profited from discussion with Richard Pittman, Kenneth Smith, and David Thomas.

Jenner (1966:37, fn. 52) has noted that the task of defining register may be approached from either the point of view of the mechanics of production or that of their perceptible effects. He says that for reasons of economy he has chosen the latter; the present study focuses on the former.

Chomsky and Halle (1968:314-15) suggest the features 'covered-noncovered' to describe the West African vowel harmony characteristics. They consider it basically a vowel related phenomenon and mainly a West African phenomenon. I suggest that this opposition is much more far-reaching than either of those observations suggest. The terms 'covered-noncovered' also seem more nebulous than necessary. Tongue-root advancement: Tongue-root retraction is more enlightening.

This indictment is not universally valid, of course, for such works as Heffner (1960) and Jakobson, Fant and Halle (1961), to mention just two, explicitly correlate pharyngeal and oral features. It does, nevertheless, reflect the fact
The topic has not received the attention it merits in view of its relevance for phonology.

5. In contrast to this, note that in Tlingit it is reported (personal communication from Constance Ish) that the vowels /i, e, a, u/ have high or low tone, but that /ɪ, ɛ, ʌ, u/ have only high tone. In this case, except for the ʌ vowel, it is the lower tones that are classed favor higher pitch.

6. In Finnish it is reported (Jakobson, Fant, and Lydekker 1961:41) that again the front vowels /e, ɪ/ do not take part in the vowel harmony process.

7. Note that historical palatalization phenomena in West African languages also coincide naturally with tongue-root advanced vowels.
REFERENCES


